Taking temperature and wind speed readings, Southern Watch.

1st Combat Camera Squadron (Richard M. Hellman)

Meteorological and Oceanographic Conditions

By BRUCE R. KITCHEN

Knowledge-based warfare helps operational commanders to prepare a theater by achieving dominant battlespace awareness, which enables them to make decisions faster than enemy leaders. It allows commanders to leverage battlespace knowledge to accomplish a mission by the precision employment of combat power. One key to knowledge-based warfare is a grasp of meteorological and oceanographic (METOC) conditions that may be encountered and their impact on the conduct of military operations. These include wind, temperature, cloud cover, wave height, salinity, and other phenomena. By recognizing METOC effects, commanders can set battle terms, maximize their own advantages, and exploit enemy limitations.

On the operational level determining effects involves much more than formulating weather and oceanographic forecasts—though forecasting plays an important role. A systematic approach which considers the impact

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of such conditions on each aspect of operational planning and execution is essential. Only then can commanders identify and exploit critical factors: conditions that directly affect friendly or enemy capabilities or otherwise influence the ability of commanders to achieve operational objectives. Using such an approach, commanders can understand and plan for the impact of these conditions on friendly and enemy forces, sensors, platforms, and weapons. This will help formulate a concept of operations. By contrast failing to determine critical METOC factors may result in disjointed or poor operational decisions.

METOC considerations were key to Allied planning during World War II

Historical Perspective

The impact of METOC conditions on warfare is well documented through history. Some commanders have used them to advantage while others have not. It is axiomatic that these conditions affect military operations, yet a determining factor between success and failure has often been how well they were accounted for in operational planning.

When Genghis Khan was planning his last campaign against the Persians he knew that the enemy would outnumber his Mongols but that they were widely separated and did not know how to conduct winter operations. To prevent the Persians from gathering their forces, Genghis timed his campaign to begin in the winter and defeated the enemy in piecemeal fashion.

Bonaparte's *Grande Armée*, which conquered most of Europe, was nearly annihilated in its attempt to invade Russia. Napoleon knew of the severity of the Russian winter but discounted its effects. Failing to prepare for the snow, rain, mud, and cold during the retreat from Moscow contributed to his defeat. Hitler met a similar fate. Operation Barbarossa was calculated to take five months; however, German planners did not adequately anticipate the Russian winter. Inclement weather blunted *Blitzkrieg* tactics, winter clothes and shelter were scarce, and equipment malfunctioned in the cold. The Germans planned insufficiently and were driven from Russia.

METOC considerations were key to Allied planning during World War II. They were most crucial in launching Operation Overlord. General Eisenhower, Supreme Allied Commander, had to review all factors before making a decision. The conditions were vital. After developing a list of METOC requirements, meteorologists studied the climatology of the region and determined that May and June were the best months to invade, a key factor in deciding to launch Overlord in June. Climatology, the study of conditions characteristic to a given region, is based on a detailed study of historical data and can provide the statistical range and the average conditions likely.

North Korea timed its invasion of the South to coincide with the summer monsoon in order to neutralize U.S. airpower with poor flying weather. But they overestimated the monsoon and quickly abandoned daytime operations because of American close air support and air interdiction.

Operation Linebacker II during the Vietnam War was designed to force Hanoi back to the negotiating table by stressing maximum effort in minimum time. Planners anticipated the need to conduct air operations during the winter monsoon, which would make the use of precision guided munitions (PGMs) difficult. In late summer they reviewed target lists for bombing by all-weather aircraft; when President Nixon needed a bombing plan in December for Linebacker II, the military was ready with one that could achieve the objective. The North Vietnamese, on the other hand, thought the winter monsoon would keep them safe by preventing American bombing north of the 20th parallel. Linebacker II caught the North's leadership by surprise and shocked them with the magnitude and destruction of the bombing, which continued night after night despite the weather.

This highlights the importance of operational planners adequately assessing the effects of critical METOC factors. Determining them is complex and requires an orderly, thorough process. The first step is to ascertain the conditions of the theater or area of operations.

Using Climatology

Climatology is most useful in planning for operations to be executed beyond the accuracy range of METOC numerical forecasting predictions, typically five to seven days. It is critical that commanders avoid planning just for average conditions. Operational planning requires knowledge of the whole spectrum of conditions and the probability of their occurrence to assess their impact. Commanders must also know the amount of data used in developing the climatology. An insufficient number of observations can skew the statistics or, more importantly, miss rare but significant conditions. Operating in remote areas of the world means limited data, requiring that assumptions be made about local METOC characteristics. Knowing the limitations and uncertainty of climatology allows commanders to weigh the risks and make timely, informed decisions.

If only the average conditions are considered or data is sparse, unexpected conditions can adversely affect the operation. An example is the Iranian hostage rescue, Operation Eagle Claw. To avoid Iranian radar, the mission was to be flown at low level, requiring visual meteorological conditions (VMC) en route. While flying from the aircraft carrier to a remote landing site (Desert One), the helicopters (one of which had already aborted because of mechanical failure) encountered suspended dust in the air which precluded VMC flight. Flight integrity was thus lost, then another helicopter was aborted, and the remaining craft reached Desert One some 85 minutes late. Insufficient helicopters and their tardiness caused mission abandonment.

During planning, the Air Weather Service team assigned to the joint task force researched Iran's climatology to identify non-VMC weather conditions aircrews could encounter. According to the final report issued by the Special

Aiming dish for meteorological satellite imagery, Deny Flight.

U.S. Air Force (Angela Stafford)

Operations Review Group for the Iranian Rescue Mission, suspended dust was identified and included in the weather annex. However, the climatology also showed a high probability of clear weather. Thus alternatives for executing Eagle Claw under conditions other than VMC were not developed, pilots were not briefed on suspended dust, and the plan did not establish weather criteria for mission abort. The forecast for the day of execution called for VMC conditions. When pilots encountered suspended dust, they were unready to assess the impact of non-VMC conditions. Had they been, they could have made an informed decision en route, including aborting the mission and preserving the option to launch it later.

ROE restraints may restrict the use of certain weapon systems in low visibility conditions

It is unrealistic to plan for every condition; commanders must decide which are important. For example, depending on the mission, they may not consider a 30 percent chance of gale force winds critical, but a 10 percent chance of fog may be. Using climatology to understand METOC characteristics of a theater or area of operations is the first step. This knowledge must then be used to determine the effects of the various conditions on friendly and enemy capabilities.

Effects of Conditions

To determine how METOC conditions affect capabilities, commanders must understand the range of conditions that people, sensors, platforms, and weapons can operate in and establish both threshold and critical values. The former is the value at which a METOC parameter begins to adversely affect performance and the latter is the value at which a parameter prevents effective performance. Applying values to climatology will allow commanders to quantify how much and how often METOC conditions will affect a possible course of action. When the operation moves into the execution phase, METOC forecast predictions will provide commanders with upcoming conditions. Having already determined the effects of forecast conditions using climatology, they can quickly assess the options available under them.

Critical and threshold values should take into account the capability of the sensors, platforms, and weapons as well as operational considerations such as the threat and rules of engagement (ROE). For instance, if anticipated heavy anti-aircraft artillery will prevent low level air strikes, high cloud ceilings may be required to employ PGMs. Similarly, ROE restraints such as a requirement to limit collateral damage may restrict the use of certain weapon systems in low visibility conditions. Therefore, commanders will have to ensure that technical data concerning the operational parameters of sensors, platforms, and weapons is accurate and available to planners. Using the wrong threshold or critical values when planning can lead to poor operational decisions, as occurred in Operation Delaware.

A helicopter assault on the A Shau Valley during the Vietnam War, Operation Delaware had the objective of preventing the enemy from massing for further attacks in the vicinity of Hue. On April 10, 1968, the 1st Cavalry Division (Airmobile) was ordered to begin planning for withdrawal from Khe Sanh and conducting Operation Delaware. The urgency of the operation was predicated on a long-range forecast, based on climatology from French records, that April would offer the last favorable weather for an air assault before the summer monsoon.

The climatology was accurate in determining the onset of the rains; however, the timing of the operation was predicated on the wrong METOC critical and threshold values. The weather during April was characterized by low cloud ceilings, fog, and thunderstorms that wreaked havoc on air operations. The Army lost 33 helicopters in Operation Delaware, primarily because cloud ceilings forced them to fly low and increased their vulnerability to anti-aircraft fire. Weather was critical to timing of the operation from the outset. Unfortunately, the decision to start in April was based on a single criterion: inches of rain expected during the summer monsoon. Forgotten in the analysis were cloud ceilings and visibility requirements for an air assault. In 1973 Major General Tolson, commander of 1st Cavalry Division during Operation Delaware, stated:

Mountain Warfare Training Center, California.

2d Marine Division (E.J. Young)

An air cavalry division can operate in and around the scattered monsoon storms and cope with the occasional heavy cloudbursts far better than it can operate in extremely low ceilings and fog. . . . The lesson learned then was that one must be careful to pick the proper weather indices in selecting an appropriate time for an airmobile operation.[1]

Thus the goal is to analyze the climatology and the operational limits of sensors, platforms, and weapons. This will enable commanders to ask the right questions to identify threshold and critical values. Only after this process can they begin to determine the critical METOC factors.

Determining Critical Factors

Joint Pub 3-0, *Doctrine for Joint Operations*, recognizes the importance of METOC considerations in operational planning.

Seasonal effects on terrain, weather, and sea conditions can significantly affect operations of the joint force and should be carefully assessed before and during operations.

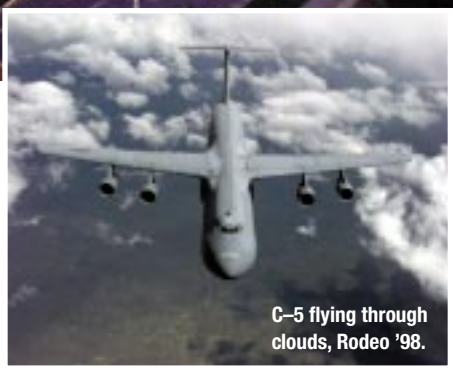
After analyzing how METOC conditions in theater will affect systems, sensors, weapons, and personnel, there will be many combinations of conditions and effects to weigh. These combinations by themselves will not give commanders a comprehensive view of the overall effects of METOC conditions on a given course of action. To get it, they must sort through the various permutations of condition and effect to determine the critical METOC factors. In that process it is important to look beyond the raw numbers to determine which conditions affect an operation. A condition may favorably influence several aspects but inhibit a single critical facet. That was the problem Allied meteorologists faced in planning Operation Overlord.

Conflicting or overlapping METOC requirements can be particularly prevalent in joint and multinational operations where varying systems, capabilities, and doctrines must be accounted for. Therefore, a framework must be established to enable commanders to adequately assess the many combinations and determine the critical METOC factors for an operation.

Operation Shingle, the landing at Anzio during World War II, showed the consequences of applying an inadequate framework to determine critical METOC factors. While designed to break the stalemate on the Italian mainland, the plan has been criticized for many reasons. Perhaps the most significant flaw was the planning for METOC effects. Planners knew bad weather and poor beaches would make

Pall over Sarajevo.

U.S. Air Force (Louis Briscese)



C–5 flying through clouds, Rodeo '98.

1st Combat Camera Squadron (Billy Johnston)

an amphibious landing difficult and that high seas would complicate logistics. An innovative plan was devised to overcome METOC conditions and offload logistics in two days. But it failed to fully account for the effects of these conditions on the flow of forces ashore.

Planners assumed the Germans would defend vigorously then counterattack. Fortunately they did not because the majority of Shingle's armor failed to reach shore the first day because of rough seas. Moreover, planners did not adequately consider the effects of METOC conditions on the ability of forces to achieve their objectives once ashore. The terrain, mud, and floods made the plain before the Alban hills in Italy the wrong time and place to fight in winter.

Operational art translates a strategy into an operational design that helps ensure the effective use of assets and time to achieve goals. The design provides a framework to enable commanders to understand the conditions for victory and order their thoughts. It can also be used to identify the critical METOC factors for the operation.

The following operational design elements suggest when METOC effects conditions should be considered.[2]

■ *Method of defeat*. Commanders will select a direct approach to defeat an enemy when friendly combat power is overwhelming and an indirect approach when it is not. Determining relative combat power is not simply a comparison of expected orders of battle. It also includes intangible combat multipliers or reducers. Conditions can be either. Commanders must discover their effect on friendly and enemy forces before determining the method to defeat an enemy.

■ *Forces and assets*. Commanders will designate the main and secondary sectors. When applying forces and assets in the main effort, they must ensure synchronized employment and have adequate forces to quickly accomplish the mission. They must consider conditions that inhibit or degrade systems, sensors, or weapons, causing synchronization problems or requiring additional forces. Conditions that optimize systems, sensors, or weapons must also be accounted for.

■ *Operational maneuver.* This consists of moving forces from their bases and along lines of operation to strike an objective. It requires timely and reliable reconnaissance and intelligence. Commanders must plan for conditions that affect moving to the objective and reconnaissance.

■ *Operational fires*. Effective and timely operational fires facilitate maneuver by friendly forces. They can also isolate the area of operations and attack key enemy functions and facilities. Reconnaissance and intelligence are crucial to selecting targets. Commanders must consider conditions that might inhibit attacking with one system and plan for alternatives. Again, they must contemplate conditions that affect reconnaissance.

■ *Sequencing.* Arranging events within an operation in the order most likely to eliminate an enemy center of gravity is sequencing. Commanders must consider conditions that affect the sequence chosen. For example, a plan may require a major amphibious landing to secure a lodgment area once sea control has been established. If acoustic conditions degrade undersea warfare to the point that sea control cannot be established, another sequence must be determined, possibly using airborne forces.

if acoustic conditions degrade undersea warfare to the point that sea control cannot be established, another sequence must be determined

■ *Synchronization.* According to the Army glossary of terms, synchronization is "the ability to focus resources and activities in time and space to produce maximum relative combat power at the decisive point." The combined elements must generate effects that exceed the sum of their individual efforts. Commanders must account for conditions that affect particular capabilities such as deep strike, special forces, or airlift. Depending on the conditions, additional forces may be required. Synchronization should be event driven. Commanders need to plan for such conditions that would delay or inhibit a crucial event, particularly for air apportionment.

■ *Phasing.* Phases may occur sequentially or simultaneously. When deciding on phasing, commanders must consider force requirements, force deployment, and supporting actions. They must plan for conditions that prevent forces from arriving on time or degrade their capability so additional forces or time are required to complete the phase.

■ *Timing and tempo.* An operation should be conducted at a point in time and tempo that exploit friendly capabilities and obstruct an enemy. If circumstances permit, commanders should consider the time of year when conditions optimize the operation for friendly forces and inhibit an enemy. When considering tempo they must know how conditions will affect personnel, matériel, and completing given events, especially in extreme circumstances. Poor conditions may require an operational pause to be built into the plan while favorable ones may allow an increased tempo.

■ *Operational momentum.* Commanders need to consider the type of force to employ to strike effectively and speedily to maintain momentum. They can take advantage of conditions to tailor their forces and must also consider the effects on an enemy's ability to react.

■ *Branches and sequels.* Branches are options built into plans and sequels are subsequent operations based on possible outcomes of ongoing events. Both increase flexibility and accelerate the operational decisionmaking cycle, allowing commanders to act faster than opponents. They can develop a basic plan based on the most probable conditions and build branches and sequels using these conditions as implementation criteria. That enables commanders to quickly shift to another option and continue an operation as changes occur in forecast conditions.

■ *Operational sustainment.* When planning an operation, sufficient time must be given for logistical build-up. Inadequate sustainment may restrict timing and sequencing and limit options for operational maneuver. Identifying logistical constraints is critical. Commanders must determine what conditions can limit logistics operations and develop plans to overcome them. They must consider conditions at the points of embarkation and debarkation and along the lines of communication. High winds and seas, fog, rain, and tropical storms affect logistic flow.

METOC conditions and their effects, synthesized by operational art, enable commanders to determine the critical factors that set the stage for mission success. They can then base plans and courses of action on the critical factors.

Boldness usually triumphs over timidity. But it must be supported with facts so that time and assets are not wasted. Determining critical METOC factors will embolden commanders. By knowing the risks before making a decision, they can resolutely take advantage of opportunities or minimize adverse effects. Operational planning helps manage risks by identifying problems and devising solutions. Determining METOC factors must be part of planning. *JV 2010* stresses the role of an emerging system of systems in acquiring dominant battlespace awareness. Recognizing conditions and their effects is critical to dominant battlespace awareness.

As Clausewitz observed: "Everything in war is simple, but the simplest thing is difficult." Determining critical METOC factors is a simple concept that is difficult to implement. Accessing and interpreting climate is cumbersome and time-consuming. The weapon, sensor, and platform data required to ascertain critical and threshold values must be retrieved from multiple sources and can be conflicting. The results are often incomplete or late. Determining critical METOC factors is only one decision commanders must make early in the planning process. Emerging technologies may allow that task to be delegated to an expert system to provide information in a timely manner. That would free commanders to think creatively about a situation and develop options.

Nothing can be done to change METOC conditions, but timely and accurate knowledge of the types of conditions to expect and their effects can be a force multiplier, enabling commanders to anticipate problems and opportunities and to be ready to act, not react.

In war, the effects of METOC conditions are never neutral, and as Sun Tzu observed over 2,000 years ago the advantage goes to the side that knows the weather. **JFQ**

NOTES

[1] John F. Fuller, *Air Weather Service Support to the United States Army: Tet and the Decade After*, Air Weather Service historical study no. 8 (Scott Air Force Base, Ill.: Military Airlift Command, 1979), p. 26.

[2] For more details, see Milan N. Vego, *Fundamentals of Operational Design* (Newport: Naval War College, 1995).